Amendments to the Specification

Please replace the third full paragraph on page 3, beginning on line 14, with the following rewritten paragraph:

It is an object of the present invention to provide a rotary module for implementing a high frequency pressure swing adsorption process with high energy efficiency.

Please replace the third full paragraph on page 4, beginning on line 21, with the following rewritten paragraph:

The flow path through the adsorbers may be radial or axial. If the adsorbers are configured for radial flow, the first valve surface would preferably be radially inward when the less strongly adsorbed gas fraction has much higher density ~~that~~ than the more strongly adsorbed fraction, and the first valve surface would preferably be radially outward when the less strongly adsorbed gas fraction has much lower density than the more strongly adsorbed fraction. Hence, for hydrogen purification in a radial flow embodiment, the feed gas would preferably be admitted to (and the higher molecular weight impurity fraction as heavy product is exhausted from) the first valve surface at an outer radius, while the hydrogen as first product gas is delivered from the second valve surface.

Please replace the second full paragraph on page 6, beginning on line 12, with the following rewritten paragraph:

Further, by providing multiple closely spaced intermediate pressure levels, with substantially constant flow and pressure at each level, the present invention facilitates energy efficient application of multistage feed compressors and vacuum pumps (including centrifugal or axial compression machines) for feed compression, heavy product exhaust and heavy reflux compression; as well as multistage expanders (including radial inflow turbines, axial turbines and partial admission impulse turbines). Positive displacement (reciprocating piston, rotary piston, or progressive cavity such as screw or scroll machines) compression and expansion machinery may also be applied within the scope of the invention, particularly when adapted to deliver gas at multiple intermediate delivery pressures and/or to intake gas at multiple

intermediate inlet pressures. The invention enables use of single shaft machines to provide all compression and expansion functions for a plurality of modules in parallel, as well as the combined use of motor driven and free rotor machines for more flexible modularization and splitting of stages. Additionally, gas mixing means, such as an ejector or jet pump may be used to mix two or more gas streams of differing pressure associated with the PSA system (such as for example a relatively higher pressure blowdown stream and a relatively lower pressure exhaust or purge stream), such that the expansion of the higher pressure stream(s) may provide a source of reduced pressure or vacuum to the lower pressure stream(s), whose pressure is increased within the gas mixing means from the ~~reduce~~ reduced pressure or vacuum thereby established. Alternatively, one or more of the gas streams entering the gas mixing means may be external to the PSA system. In such a way, a gas mixing means such as an ejector or jet pump may be used for example to expand a blowdown or other relatively higher pressure gas stream and to provide a source of vacuum to a purge or exhaust stream, thereby increasing the efficiency of the purge or exhaust step. Further, two or more such gas mixing means may be applied in a single gas separation module or cooperating series of modules to provide for mixing of multiple sets of gas streams, to provide sources of reduced pressure or vacuum to multiple process gas streams, such as exhaust and purge streams, to increase the overall efficiency of the gas separation module(s).

Please replace the paragraph beginning on line 24, page 8, with the following rewritten paragraph:

Fig. 23 shows an adsorber wheel ~~configurations~~ configuration based on laminated adsorbent sheet adsorbers for the embodiment of Fig. 19;

Please replace the second full paragraph on page 15, beginning on line 4, with the following rewritten paragraph:

The laminate sheets 115 lie in the radial plane and are layered to form the adsorber elements 24 as rectangular blocks. Each sheet 115 comprises reinforcement material, e.g. a glass fiber or metal wire matrix (woven or non-woven) on which the adsorbent material (e.g. zeolite crystallites) is supported by a suitable binder (e.g., clay, silicate or coke binders). Typical thickness of an adsorbent sheet may be about 100 microns. The sheets 115 are installed with spacers on one or both sides to establish flow channels between adjacent pairs of sheets. The

flow channels define the flow path approximately in the radial direction between first end 30 and second end 32 of the flow path in each adsorber element. Typical channel height would be about 50% to 100% of the adsorbent sheet thickness.

Please replace the third full paragraph on page 16, beginning on line 11, with the following rewritten paragraph:

The horizontal axis 155 of Figs. 6 and 7 indicates time, with the PSA cycle period defined by the time interval between points 156 and 157. At times 156 and 157, the working pressure in a particular adsorber is pressure 158. Starting from time 156, the cycle for a particular adsorber (e.g. 24) begins as the first aperture 34 of that adsorber is opened to the first feed pressurization compartment 46, which is fed by first feed supply means 160 at the first intermediate feed pressure 161. The pressure in that adsorber rises from pressure 158 at time 157 to the first intermediate feed pressure 161. Proceeding ahead, first aperture passes over a seal strip, first closing adsorber 24 to compartment 46 and then opening it to second feed pressurization compartment 50 which is ~~feed~~ fed by second feed supply means 162 at the second intermediate feed pressure 163. The adsorber pressure rises to the second intermediate feed pressure.

Please replace the first full paragraph on page 20, beginning on line 3, with the following rewritten paragraph:

Where any of the light reflux pressure let-down means ~~170—176~~ 170, 172, 174 and 176 or any of the exhaust means ~~181—184~~ 181, 183 and 184 are gas expanders or turbines or turbine stages, they may be used to recover useful mechanical work from gas expansion, e.g. to drive compressor or vacuum pumps associated with the PSA system, or to drive rotation of rotor 11, directly as drive motor 95 or to assist a separate drive motor 95.

Please replace the third full paragraph on page 20, beginning on line 15, with the following rewritten paragraph:

It would be much less desirable to drive the rotor by expansion of light product gas from the upper pressure 151 as purge gas to the lower pressure 152 (as has been proposed in the prior art), since any increase of light product flow 166 would decrease the purge gas flow through the

expander acting as drive motor 95, thus reducing the rotor speed just when increased rotor speed may be needed to maintain PSA process performance (e.g. light product purity at increased light product flow rate). Conversely, a decrease of light product flow would increase the purge gas flow through the expander, thus increasing the rotor speed just when a ~~crease~~ decrease in rotor speed may be more appropriate.

Please replace the first full paragraph on page 27, beginning on line 1, with the following rewritten paragraph:

The apparatus of Fig. 11 is configured to accept first and second feed gas mixtures, the first having a higher concentration of the less readily adsorbed component (e.g. hydrogen) while the second is more concentrated than the first feed gas mixture in the more readily adsorbed fraction. The first feed gas is supplied at substantially the higher working pressure by first infeed conduit 280 to first feed manifold 53, while the second feed gas is supplied at substantially the higher working pressure by second infeed conduit 281 to ~~first~~ second feed manifold 55. Each adsorber receives the second feed gas after receiving the first feed gas, so that the concentration profile in the adsorber is monotonically declining in concentration of the more readily adsorbed component along its flow path from first end 34 to second end 35 of the flow path in adsorber element 24. All but the final pressurization steps are here achieved with light reflux gas. The final feed pressurization (from the third light reflux pressurization pressure 192 directly to the higher pressure 151) is achieved as the first end of each adsorber is opened to compartment 52 communicating to manifold 53. Additional feed pressurization steps could readily be incorporated as in the embodiment of Fig. 8.

Please replace the first full paragraph on page 33, beginning on line 2, with the following rewritten paragraph:

Fig. 18 shows a radial flow rotary PSA module 500, contemplated for tonnage oxygen generation. With reference to Fig. ~~17~~ 18, this view may be interpreted as an axial section through compartments 54 and 70 at the higher pressure, and compartments 80 and 60 at the lower pressure. Arrows 501 and 502 respectively indicate the feed and exhaust flows. Rotor 11 has a first end plate 510 with stub shaft 511 supported by bearing 512 in first bearing housing 513, which is integral with first valve stator 40. Rotor 11 is attached at assembly joint 514 to a

second end plate 515 with stub shaft 516 supported by bearing 517 in second bearing housing 518, which is attached at assembly joint 519 to first valve stator 40.

Please replace the second full paragraph on page 34, beginning on line 15, with the following rewritten paragraph:

Because of the compactness (similar to an automotive turbocharger) of a "turbocompressor" oxygen booster as described for ~~Fig. 17above~~ Fig. 18 above, it is possible to install a split stream light reflux expander 220 with close-coupled light product compressor 396 inside the light valve stator. Compressed oxygen product is delivered by conduit 218.

Please replace the first full paragraph on page 35, beginning on line 3, with the following rewritten paragraph:

At the ends of rotor 11, circumferential seals ~~608~~ 6081 and 609 bound first sealing face 21, and circumferential seals 610 and 611 bound second sealing face 23. The sealing faces are flat discs. The circumferential seals also define the ends of seals between the adsorbers, or alternatively of dynamic seals in the sealing faces between the stator compartments. Rotor 11 has a stub shaft 511 supported by bearing 512 in first bearing housing 513, which is integral with first valve stator 40. Second valve stator 41 has a stub shaft engaging the rotor 11 with guide bushing 612.

Please replace the fourth full paragraph on page 35, beginning on line 22, with the following rewritten paragraph:

Fig. 20 shows an axial flow rotary PSA module 650 with twin adsorber wheels. The same reference numerals are used as in Fig. 19 for the first adsorber wheel 608, and primed reference numerals are used for the second adsorber wheel 608', which are assembled together as rotor 11. Module 650 has two first valve faces 21 and 21', each with a full set of feed supply and second product exhaust compartments. External manifolds will be provided to supply feed fluid to each pair of feed compartments and to withdraw exhaust fluid from each pair of exhaust compartments. Module 650 has two second valve faces 23 and ~~219'~~ 23', which share a common set of compartments for light product delivery, light reflux exit and return, and purge. Arrows

651 indicate the flow direction in compartment 221, and arrows 652 indicate the flow direction in compartment 70.

Please replace the first full paragraph on page 36, beginning on line 7, with the following rewritten paragraph:

Rotor 11 is driven by shaft 94 coupled to the first adsorber wheel 608. The adsorber wheels ~~408~~ 608 and 608' are attached at joint 655. Flanged cover plate 615 of Fig. 19 is here replaced by the first valve stator 40' for the second adsorber wheel 608', in the role of connecting the first valve stator 40 and second valve stator 41 to form an enclosed housing for the module. A small diameter dynamic seal 660 is mounted adjacent bushing 612', to prevent leakage between the first and second valve faces.

Please replace the first full paragraph on page 47, beginning on line 4, with the following rewritten paragraph:

In the case of an air separation PSA to generate enriched oxygen as the light product, and with ~~nitroogen-enriched~~ nitrogen-enriched exhaust as heavy product discharged from conduit 243 at atmospheric pressure, the ejector 900 is a source of modest but useful vacuum in compartment 61 so as to reduce the lower pressure and to increase oxygen yield and productivity. In the case of a hydrogen purification PSA, the ~~heagy~~ heavy product exhaust will typically be delivered to a tail gas burner operating at above atmospheric pressure, and ejector 900 is a source of pressure reduction of the lower pressure in compartment 61 so as to increase hydrogen recovery and productivity.

Please replace the abstract with the following rewritten abstract:

ABSTRACT

A rotary module for implementing a high frequency pressure swing adsorption process comprises a stator and a rotor rotatably coupled to the stator. The stator includes a first stator valve surface, a second stator valve surface, a plurality of first function compartments opening into the first stator valve surface, and a plurality of second function compartments opening into the second stator valve surface. The rotor includes a first rotor valve surface in communication with the first stator valve surface, a second rotor valve surface in communication with the second

stator valve surface, and a plurality of flow paths for receiving adsorbent material therein. Each flow path includes a pair of opposite ends, and a plurality of apertures provided in the rotor valve surfaces and in communication with the flow path ends and the function ports for cyclically exposing each ~~said~~ flow path to a plurality of discrete pressure levels between the upper and lower pressures for maintaining uniform gas flow through the first and second function compartments.